TAGGING AND TRACKING OF STENELLA SPP. DURING THE 2001 CHASE ENCIRCLEMENT STRESS STUDIES CRUISE

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JUNE 2002

ADMINISTRATIVE REPORT LJ-02-33

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ABSTRACT

During the 2001 Chase Encirclement Stress Studies (CHESS) cruise, 9 pantropical spotted dolphins (*Stenella attenuata*) were radio tagged and tracked and 6 spotted dolphins were satellite tagged and tracked. The dolphins tracked with VHF radio tags also carried time-depth recorders (TDRs) (n=3), time-depth-velocity recorders (TDVRs) (n=4) or time-depth-velocity-heat flux recorders (thermal) (n=2). We recovered 2 TDRs, 2 TDVRs and both thermal tags. Dolphins were tracked from 1 to 6 days. Satellite tagged dolphins were tracked from 2 to 20 days. One additional TDR/VHF radio tag was deployed on an eastern spinner dolphin (*Stenella longirostris orientalis*) but was not tracked. We also attached 213 visual tags (all spotted dolphin) and 8 short-range radio tags (1 spinner and 7 spotted dolphins) to obtain information about dolphin associations in the herds that we captured. This report summarizes the dolphin movement patterns and dive characteristics as well as our observations about herd dynamics.

INTRODUCTION

Pantropical spotted dolphins, *Stenella attenuata*, frequently associate with yellowfin tuna, *Thunnus albacares*, in the eastern tropical Pacific (ETP). This association has been exploited to catch tuna for more than four decades. While incidental dolphin mortalities in this fishery are currently low (Joseph 1994, IATTC 1999), high mortalities during the early years of the fishery depleted the northeastern stock of pantropical spotted dolphin to less than 50% of its original abundance (Smith 1983, Wade and Gerrodette 1993, Wade 1993). During the 1970s, management-oriented research on the dolphins focused on distribution and stock structure, abundance and fishery mortality estimation, vital rates and behavior. All studies were designed to better understand the dynamics of the dolphin populations and the impacts of the fishery on them. Gear modifications to reduce dolphin mortality in tuna purse-seine nets were also investigated and implemented in the fishery. Concern that the dolphin population was not recovering even though mortality had been low for many years, led to a Congressional mandate written into the 1997 International Dolphin Conservation Act (IDCPA) to conduct three years of population abundance surveys and a series of studies to examine physiological stress in the dolphins. The Chase Encirclement Stress Studies (CHESS) cruise conducted in August through October 2001 was one project specifically mandated by Congress to address questions of whether the fishery causes sufficient stress to dolphins during chase and encirclement to hinder recovery of the population.

Spotted dolphins have been radio-tracked previously in the eastern and central Pacific (Perrin *et al.* 1979, Leatherwood and Ljungblad 1979, Scott and Wussow 1983, MS and SC, unpub.data). While the development of smaller radio-transmitters and sophisticated time-depth recorders (TDRs) continually improves our ability to collect more detailed data on their behavior in three dimensions, we are still trying to understand their daily movement and dive behavior. TDRs can sample depths every second and either transmit summary information via satellite or store complete chronological histories of dives for later recovery. TDRs have provided such detailed dive histories for a number of free- ranging cetacean species (see review by Hooker and Baird 2001). Our radio- and satellite- tracking effort focused on pantropical spotted dolphins during the 2001 CHESS cruise. In this paper, we present the movements of the focal dolphins tracked, and their diving patterns as recorded by TDRs. The patterns recorded in the diving and movement data allowed us to identify diurnal and nocturnal activity patterns and to describe behavior associated with chase, capture and release by tuna purse seiners. We also used visual tags to mark additional dolphins in each herd captured, which provided us data on individual associations within the herds. We used these data to provide a description of herd dynamics.

An independent scientific peer review of this work was administered by the Center for Independent Experts located at the University of Miami. Responses to reviewer's comments can be found in the Appendix.

METHODS

The CHESS cruise was conducted during 58 days aboard the NOAA ship, R/V *McArthur* (54 m long), and a chartered purse seine vessel, between 8 August and 4 October 2001. Our study area was approximately 300 nm off the coast of Central America (Fig. 1).

Capture and Tagging Methods

Pantropical spotted dolphin herds and mixed spotted/eastern spinner dolphin (*Stenella longirostris orientalis*) herds were encircled by the purse-seine net (see Coe and Sousa 1972, for a description of the purse-seining process). After the dolphins were encircled, the bottom of the net pursed, and two-thirds of the net rolled on deck, individual dolphins were caught as they swam in the net circle by a team of swimmers and placed in a partially flooded raft for processing: tag attachment and blood sampling.

Two types of VHF radio transmitter were deployed. Focal dolphins were outfitted with a 'boomer' VHF radio transmitter (Model MOD-050-HP with a TA-6H semi-rigid, stainless steel antenna, 148 MHz: Telonics, Mesa AZ) mounted on a molded plastic saddle (Trac Pac, Fort Walton Beach, FL) padded on the inside with a bilayer of 2-mm Blue Poron and 2-mm Blue Puff, which is used as padding to reduce skin irritation in human prosthetic devices. Saddles were attached to the dorsal fin with two or three 1/4-in. (0.64-cm) Delrin pins secured by magnesium nuts. The magnesium nuts corrode in seawater causing the package to be released in a few days or weeks. The transmitters were designed to provide maximum range, relatively long signals (30 msec), and a frequent transmission rate (2/sec), all at the expense of longevity (conservatively estimated to be about 2 weeks).

The 'boomer' VHF radio transmitters were packaged with either a time-depth recorder (TDR; Model Mk 7: Wildlife Computers, Woodinville, WA) or a time-depth-velocity recorder (TDVR; Model Mk 8: Wildlife Computers, Woodinville, WA) (Fig. 2). The TDRs or TDVRs were set to record time and depth every second, except for one of the TDVRs, which was set to sample every four seconds. All TDRs and TDVRs measured depths to 500m with 0.25m resolution. To recover the data recorded by these instruments, the instrumented dolphin had to be re-captured. A third type of datalogger, the time-depth-velocity-heat flux recorder, or "thermal" tag, was deployed on two dolphins and is described in Pabst *et al*. (2002).

The second type of radio tag attached to some dolphins caught in association with the focal dolphins was a shorter-range 'bullet' VHF radio transmitter (Model 040 with a TA-5H flexible, multi-stranded stainless steel antenna, 148 MHz: Telonics, Mesa AZ). These radio tags were attached to the dolphin through a single hole in the trailing edge of the dorsal fin. We used pins from the AgriTag visual tags (see below) to attach the transmitter, after cutting away the tag flaps.

Two models of satellite tags were deployed on spotted dolphin. We deployed either a satellite-linked data recorder with a depth sensor (Model SDR-T16, Mold 87, Wildlife Computers, Woodinville, WA) or one without a depth sensor that reported geolocation data only [ModelSPOT2, Mold 126, Wildlife Computers, Woodinville, WA]. These tags were duty cycled to transmit daily or every third day.

Other dolphins in the herd were visually tagged ("rototagged", Scott *et al*. 1990) for later identification with either AgriTag (sheep/goat model with an antibacterial coating on the pins, AgriLaboratories, St. Joseph, MO) or Jumbo roto tags (Dalton, Nettlebed, England) (Fig. 2). The dolphins selected for visual tagging were those that had a skin biopsy or a blood sample collected.

The tagging process for the 'boomer' VHF tags averaged 4.8 min (range: 4 to 6 min) and for the satellite tags averaged 6.8 min (range: 4 to 11 min). Bullet-tags were attached in 1-2 minutes. Total body length, sex and color pattern were recorded and blood samples collected from all dolphins. The dolphins were released inside the net, and when the processing of all dolphins was complete, the entire herd was released during the backdown process (see Coe and Sousa 1972).

Tracking methods

An array of four 3- or 4-element Yagi-Uda antennas oriented at 90º intervals was mounted on the masts of the *McArthur* (about 17 m above the waterline) and purse seiner (about 22 m above the waterline). The cables from each of the array's four antennas were connected to pre-amplifiers (to reduce signal loss) and then to a directional indicator (Advanced Telemetry Systems, Inc., Isanti MN) linked to a receiver (Model TR-2 with a Model TS-1 scanner/programmer: Telonics, Mesa AZ). This system sampled 5-msec segments of the signal from each of the antennas in sequence, allowing the signal strengths received by each antenna to be compared, and thus an approximate bearing from the vessel to be determined. A digital data processor (Model TDP-2: Telonics, Mesa AZ) provided an estimate of signal strength to obtain an estimate of distance to the transmitter. Even though signal strength is a product of more factors than just distance, calibration tests and triangulation of multiple bearings suggested that the signal strength could provide a reliable indication of distance. A portable tracking system consisting of an "H" antenna (RA-2H) and a scanning receiver (Model TR-2 with a Model TS-1 scanner/programmer: Telonics, Mesa AZ) was used to track from the purse seiner's helicopter.

During tracking, care was taken not to affect the behavior of the animals. Most of the tracking was conducted from the *McArthur*, supplemented at times from the purse seiner or the purse seiner's helicopter. The purse seiner usually approached the dolphins only when attempting to recapture them, and at other times kept at a distance so as not to affect the dolphins' behavior. When radio tracking, the position, time, heading of the vessel, bearing to the dolphin, and signal strength were recorded every 15 minutes. Surfacing times were also recorded for at least 15 min out of every hour when possible (radio signals were only received when the transmitter antenna cleared the surface of the water). Surfacing times and dive durations were also collected from the TDRs or TDVRs.

Environmental Data

An expendable bathythermograph (XBT) was deployed from the *McArthur* approximately every 4 hr while tracking to measure the depth profiles of temperature. Observations of sea state, wind strength, and cloud cover were recorded hourly.

Dive Analyses

Dive-analysis, a program supplied by Wildlife Computers (Woodinville, WA) was used to extract the following diving parameters from data stored on the TDRs: dive depth, dive duration, surface time, bottom time, and ascent and descent rates. However, only dive depths were analyzed for this report. Dives were defined as recorded events ≥ 5m.

Velocity Analyses

Average velocity was calculated separately for the following events: chase by the seiner, swimming in the net, release from the net (after backdown), daytime travel, and nighttime travel and feeding. Velocity was recorded in m/sec, but the tags were not calibrated. Positioning of the tags deployed was essentially the same on each dolphin, so the estimates were considered comparable. We converted all velocity estimates to knots.

RESULTS

All of the spotted dolphin herds were captured within the geographic range of the northeastern stock of spotted dolphin (Dizon *et al.* 1994). All spinner dolphins were morphologically consistent with the descriptions of the eastern spinner dolphin, *Stenella longirostris orientalis* (Perrin 1990). During CHESS, spinner dolphins were only captured in mixed herds of spotted and spinner dolphins.

Tagging and Tracking Effort

During CHESS, 28 sets were made on dolphins (Table 1). One spotted dolphin was designated as the focal dolphin to be tracked in 15 of 28 sets. There were nine focal dolphins tracked using the 'boomer' radio tags. In Set 2, two animals were tagged with 'boomer' radio tags: one pantropical spotted dolphin and one eastern spinner dolphin. However, the spotted dolphin was selected as the focal dolphin for tracking, and the spinner dolphin was not seen again. Details of the focal dolphins tagged (*i.e*., their sex, tag package carried, number of chases and recaptures), and their tracks (*i.e*., distance traveled and average speeds) are summarized in Table 2. Visual (i.e., roto-tags) or 'bullet' tags were deployed during 19 of the 28 sets (Table 1). We attached 213 visual tags (all spotted dolphin) and 8 short-range radio tags (1 spinner and 7 spotted dolphins) and recorded re-sights of these tagged dolphins in subsequent sets. We used the re-sight data of marked dolphins to describe herd dynamics. More detail about the roto-tagged dolphins that had blood samples collected can be found in St. Aubin (2002), and detail about those with skin samples collected can be found in Dizon *et al*. (2002).

Seven of the nine focal dolphins tracked were recaptured and their tags removed after 1-6 days. One dolphin was recaptured three times, another dolphin was recaptured twice, and the other five dolphins were recaptured only once. Although the maximum number of recaptures was three, we know that Dolphins D29 and D47 were chased seven times during the course of this experiment (Table 2). We did not observe any migration of the pins through the dorsal fin, although we did observe pressure necrosis at some attachment sites when the saddles were attached too tightly.

We tested the radio-tracking system on the *McArthur* in the field and estimated a range of about 7 miles for the 'boomer' tags and about 3 miles for the 'bullet' tags. The dolphins typically did not appear to react to or avoid the *McArthur* when tracking from 2 miles away. However, dolphins increased their speed and activity level whenever the purse seiner came near or its helicopter was overhead.

Movements

Nine focal dolphins were tracked for up to 6 days (Table 2), and six dolphins were satellite tracked for up to 20 days (Table 3). Dolphin D29's track provides an example of the fine-scale movements observed for all focal dolphins tracked (Figure 3). A composite track for the nine focal radio- and six satellite-tagged dolphins tracked was plotted over a contour plot of thermocline depth (Figure 4). The thermocline was defined as the depth of the 20º C isotherm. The focal dolphins traveled from 71 to 134 nm per day with a median swimming speed of 4.2 kn (mean = 4.2 kn). These estimated distances were the straight-line path of the dolphin recorded while tracking from the *McArthur* and likely underestimate the actual distance traveled by the dolphins.

Dive Patterns

We recovered two of four TDRs deployed and two of four TDVRs. The TDRs were recovered from Dolphin D29 after 6 days and Dolphin D47 after two days. TDVRs were recovered from Dolphin D19 and Dolphin D230 after 1 day each. All four dolphins displayed diurnal differences in diving patterns similar to those observed for the pantropical spotted dolphins tracked during 1992 and 1993 (MS and SC, unpub. data).

During the daytime, the dolphins typically dove 5-20 m and swam at depth before returning to the surface (Fig. 5). Daytime dives were generally U-shaped with little change in depth at the bottom of the dive. The median dive depths were 9 to 11 m, and only a few dives exceeded 20 m. Virtually all of the daytime dives were above the thermocline, which averaged 27.9 m for D29, 23.2 m for D47, 24.6 m for D19, and 34.9 for D230. This average was calculated from all XBT drops made during the focal dolphin's track. The range of thermocline depths observed during each focal dolphin's track is included in Table 2.

At dusk, all four dolphins with dive depth records began to dive deeper, typically well below the thermocline. Diving bouts began about 30 min after sunset and lasted until about 30min before sunrise. Most of the dives made were characterized by rapid up and down movements at depth. The median dive depths were 12 to 18 m, although 1/3 or more of the dives were >20 m. Throughout the night, the dolphins generally continued to make deep dives well below the thermocline, although the pattern varied from one night to the next (Fig. 6).

Diving and Swimming Behavior During Purse-Seine Operations

The dolphins appeared to react first to the presence of the helicopter overhead. The helicopter was generally at a low altitude 2-25 nm ahead of the seiner searching for dolphin herds or for a marked dolphin within a herd (*i.e.*, a dolphin carrying a radio-tag package or a roto-tag). Once the helicopter was overhead the dolphins could be seen to start moving rapidly; and their speed increased as the purse seiner closed to within 2 miles. Therefore, for the purpose of measuring the effects of stress in this study, the start of the chase was equated to the time the helicopter was overhead. Historically, however, chase has been defined, for the purpose of categorizing set operations, as beginning with the launch of the first speedboat.

The TDVRs deployed provided us detailed data on the change in speed of dolphin movements during purse-seine operations that have not been documented previously. The general pattern of swimming behavior shown in the TDVR records was similar to that of the ”fly-glide” motion (Fig. 7) that characterizes the swimming of large tunas (Holland *et al*. 1990). Using data collected by the TDVRs we recovered from D19 and D230, we summarized the speed of movement of the dolphins during the chase, in the net and after release from the net as well as their average velocities for daytime and nighttime travel (Table 4).

DISCUSSION

Movements

The overlay of focal dolphin tracks on thermocline depth showed that we worked at the northern boundary of the North Equatorial Countercurrent during CHESS (Wyrtki 1966). The characteristic thermocline ridge of this area has been correlated with increased biological production and has been shown to be prime spotted dolphin habitat (Au and Perryman 1985, Reilly 1990). Most of our focal dolphin tracks were on the thermocline ridge, primarily where the thermocline was shallowest. Our satellite tagged dolphins also generally stayed in the ‘working’ area, and their tracks were also primarily where the thermocline was shallow (Fig. 4).

The movement patterns of dolphins tracked during CHESS were comparable to those observed for the offshore spotted dolphins tracked during 1992 and 1993. Dolphins moved an average of 71-134 nm/day (mean = 102 nm/day) at a median speed of 4.2 kn (mean = 4.2kn) during CHESS (n = 9) compared to 60-130 nm/day with a median swimming speed of 3.1 kn (mean = 3.7 kn) during the 1992 and 1993 studies (n = 11)(MS and SC, unpub. data).

Dive Patterns

Day and night patterns of diving were also comparable between the 1992 and 1993 studies and this study. Daytime dives were mostly U-shaped with essentially flat bottoms. Although nighttime dives were also U-shaped, they were characterized by rapid changes in depth at the bottom of the dive. Because one might expect rapid changes in depth by predators chasing prey in a three-dimensional environment (Bengtson and Stewart 1992, Testa 1992), these dives were likely associated with feeding behavior, while the daytime dives were most likely associated with traveling behavior. Additional evidence that daytime dives may be associated with travel was provided by the average daytime speeds, which exceeded average nighttime speeds for all focal dolphins (Table 2). The overall average speeds were 4.9 kn and 3.7 kn for daytime and nighttime travel, respectively.

Diving and Swimming Behavior During Purse-Seine Operations

In the four dive records recovered, the dolphins typically swam rapidly near the surface (< 5 m deep) while being herded by the purse seiner and their speedboats. After encirclement by the net, the dolphins began to mill and stayed together in a tight formation. Underwater observations of dolphins encircled, and the dive records we recovered, showed that the dolphins frequently dove 10-15 m inside the net. After release, however, the dolphins swam rapidly near the surface. Recorded dive depths rarely exceeded 5 m until after the dolphins slowed down to their average daytime speed.

Our best estimates of speeds for dolphin travel and their response to purse seine fishing activities were from the TDVRs recovered. Both chase and post-release speeds exceeded the speeds of normal travel or feeding. Estimated chase speeds from the TDVR data were 3.4 kn and 5.7 kn for D19 and D230, respectively. These estimates were reasonably consistent with the estimated average minimum speed of 5.3 kn (sd = 2.44, n=12) for dolphins chased in 1992 and 1993 (MS and SC, unpub. data). Estimated post-release speeds were the highest sustained swimming speeds recorded by the TDVRs: 5.2 kn and 6.2 kn, respectively for D19 and D230. Dolphins D19 and D230 slowed to an average of 2.7 to 3.7 kn, after swimming at their post-release speeds for 106 and 90 min, respectively (Table 4).

Herd dynamics

The ability to obtain an adequate sample size of repeat captures of dolphins that were not focal animals (*i.e*., those whose blood values would not be confounded by the effects of carrying a package with both a radio transmitter and data logger) depended greatly on the dynamics of the dolphin herds. Herds that were relatively stable in size and individual membership would aid in getting larger sample sizes, while herds with highly variable membership would be more problematic. We know from purse seiner observer data that spotted, spinner and common dolphin herds increase in number throughout the day, and then fragment at night when they feed (Scott and Cattanach 1998). Radio tracking studies also have shown this pattern of daytime aggregation and nocturnal fragmentation for spotted dolphin (Perrin et al. 1979, MS and SC, unpub. data). Many other dolphin species have “fission-fusion” societies, where group membership varies from day to day (*e.g*., Connor and Peterson 1994).

While the expectation was that dolphin herds encountered during CHESS would be dynamic in size and membership, previous tracking studies had observed smaller subgroups within the herds that were more stable over at least a period of a day or more (MS and Sc, unpub. data). By setting on small portions of the large herds encountered, it was thought that the chances of tagging multiple dolphins from a stable subgroup would be enhanced. However, the herds proved to be even more dynamic than anticipated. Eight spotted dolphins captured in association with the nine focal dolphins were also radio-tagged. Of these eight, only one (12.5%) was still in association with the focal dolphin (or even within the 3 nm radio range) the next day. Of the 90 roto-tagged or radio-tagged dolphins (all non-calves) in association with the nine focal radio-tagged dolphins, only 11 (14%) were still in association with the focal dolphin the next day. We did not observe any marked dolphins, including the satellite-tagged dolphins, to rejoin a herd we encountered on any subsequent days.

ACKNOWLEDGEMENTS

The success of this project was dependent on the cooperation, experience, and skill of the captains and crews of the NOAA R/V *McArthur* and the chartered purse-seiner. The skipper of the purse seiner demonstrated extraordinary skill and patience, which combined with his crew’s experience and skill allowed us to capture and release the dolphins as safely and effectively as possible. The skill and persistence of these skippers and their crews resulted in multiple recaptures of tagged dolphins. CDRs Michelle Bullock and Craig Bailey together with their crew on the R/V *McArthur* provided support, advice and encouragement to safely conduct our operations. We thank them all. Conducting this cruise also took a small army of people on the beach. We extend our thanks to Lt. Anne Nimershiem and Lt. Jason Appler for their expertise as SWFSC Survey Coordinators and to Laura Bowling, Barbara Decker, Andy Dizon, Carrie LeDuc, Merle Marrow, Kelly Robertson, Larry Robertson and Barbara Watkins for hiring, buying, fixing and packing gear prior to departure. We also thank the biologists who accompanied us in the field: Eric Archer, Dave Bratten, Kerri Danil, Karin Forney, Roger Geertsema, Jim Gilpatick, John Hyde, Bill McLellan, Erin Meagher, Greg O'Corry-Crowe, David St. Aubin, Forrest Townsend, Andrew Westgate, Suzanne Yin, Ernesto Vasquez, and especially our ace tracker, Jeremy Rusin. Josh Fluty kindly processed the XBT data collected in the field for analyses.

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Table 1. A list of sets made during 2001 Chase Encirclement Stress Studies Cruise. The date, location and begin time ("Chase Start Time") is listed for each set as well as the Dolphin number of the tagged dolphin selected as the focal dolphin tracked and a summary of the number of dolphins tagged and sampled. Focal dolphins accompanied by a calf are indicated with an asterisk.

			Chase		Tags Deployed:					Number of Dolphins:				
	Date		Start	Focal	'Boomer'	'Bullet'	Thermal	Satellite	Roto	with Blood				
Set	in 2001	Position	Time	Dolphin ID	VHF Tags	VHF Tags	Tags	Tags	Tags	Collected	Marked	Biopsied	Resighted	COMMENTS
1	18-Aug	10°45'N 97°47'W	1100	D12	1	0	0	1	1	3	0	4	0	Approx. 200 spotteds encircled, all but 60 released early.
2	20-Aug	10°10'N 98°31'W	0656	D19 (missed D12)	2	3	0	0	4	9	0	22	0	Approx. 500 in net. Mostly spotted, about 25 spinners.
3	22-Aug	9°56'N 98°56'W	0828	D19	0	1	0	1	0	4	0	0	1	50-60 spotteds.
4	23-Aug	10°30'N 98°31'W	1205	(recover D19)	0	0	0	0	0	0	0	0	1	Approx. 8 spotteds in net.
5	26-Aug	11°7'N 98°18'W	0756	(aborted)	0	0	0	0	0	0	0	0	0	Set aborted due to strong currents.
6	28-Aug	10°13'N 98°35'W	0745	D29*	1	1	0	1	3	6	0	0	0	15 spotteds in net. 2 two-tones.
7	30-Aug	11°37'N 98°40'W	0730	D29*	0	0	0	1	5	5	0	2	1	60-75 spotteds in net.
8	30-Aug	11°37'N 98°31'W	1357	D29*	0	0	0	0	14	6	0	0	1	Approx. 20 spotteds in net
9	3-Sep	10°50'N 99°25'W	0713	D29*	0	0	0	0	4	2	0	0	0	Approx. 100 spotteds in net. Tried to recapture D29 but missed.
10	3-Sep	10°49'N 99°15'W	1030	D29*	0	0	0	0	0	0	0	0	0	Tried to recapture D29, but missed again.
11	3-Sep	10°50'N 99°8'W	1304	D47 (recover D29*)	1	0	0	0	0	2	0	0	2	3 spotteds encircled.
12	5-Sep	9°58'N 99°45'W	0721	(recover D47)	0	0	0	0	0	2	0	0	3	3 spotteds in net; D47, D29 & calf.
13	5-Sep	10°13'N 99°37'W	0945	(no focal)	0	0	0	0	13	0	0	0	0	29 spotteds in net.

14	6-Sep	9°58'N 99°45'W	0632	(no focal)	0	0	0	0	21	0	0	0	0	27 spotteds in net.
15	6-Sep	10°8'N 99°39'W	1106	(no focal)	0	0	0	0	6	0	0	2	0	33 spotteds in net. 2 two-tones biopsied.
16	7-Sep	10°25'N 98°47'W	0626	(no focal)	0	0	0	0	13	0	0	0	0	24 spotteds in net.
17	8-Sep	11°16'N 99°10'W	1105	(no focal)	0	0	0	0	13	0	0	0	0	15 spotteds in net.
18	9-Sep	11°42'N 99°22'W	0800	(no focal)	0	0	0	0	17	0	0	2	0	33 spotteds in net. 2 two-tones biopsied.
19	9-Sep	11°48'N 99°20'W	1040	(no focal)	0	0	0	0	27	0	0	0	0	46 spotteds in net.
20	13-Sep	11°30'N 98°13'W	(not recorded)	D42	1	0	0	0	0	1	0	0	0	80-100 spotteds in net.
21	14-Sep	12°29'N 98°42'W	1251	D60 (recover D42)	1	0	0	0	28	5	0	0	1	70 spotteds in net.
22	15-Sep	13°17'N 98°39'W	0815	(missed D60)	0	0	0	0	5	4	1	0	3	27 spotteds in net. 2-3 two-tones.
23	19-Sep	11°50'N 97°51'W	0800	D63	0	2	1	1	17	6	0	0	0	25-30 spotteds in net. 2-3 two-tones.
24	20-Sep	11°58'N 98°21'W	0743	(recover D63)	0	0	0	0	3	8	3	0	5	Approx 12 spotteds in net.
25	22-Sep	10°23'N 98°12'W	1135	D227	0	0	1	1	17	5	0	0	0	22 spotteds in net. 2 two-tones.
26	25-Sep	11°45'N 96°51'W	0757	(missed D227)	0	0	0	0	0	0	0	0	0	Skunk set.
27	25-Sep	11°35'N 96°31'W	1448	D230* (recover D227)	1	1	0	0	2	7	0	0	4	18 spotteds in net (3 previously roto-tagged + D230).
28	26-Sep	11°34'N 95°55'W	0801	(recover 230*)	0	0	0	0	0	1	0	0	1	2 spotteds encircled – D230 and calf.

Table 2. Summary data for the 9 focal dolphins tracked. All of these dolphins were pantropical spotted dolphin (*Stenella attenuata*).

Dolphin ID	Sex	Tag Type	# Chases	# Recaptures	Track Length (hours)	Total Distance Traveled (nm)	Ave. Speed (knots)	Day Time Ave. speed (knots)	Night time Ave. speed (knots)	Time-Depth Recorder Data Max. Depth (m)	Time-Depth Recorder Data Ave. speed (knots)	20°C Isotherm Ave. Depth (m) (Range)
D12	F	TDVR	1	0	45.9	191	4.2	4.8	3.6			24.9 (22.0-29.7)
D19	M	TDVR	3	2	75	277	3.7	4.1	3.2	28	2.76	24.9 (18.8-30.4)
D29	F	TDR	7	3	146.1	530	3.6	4.1	2.9	51		27.1 (16.2-39.4)
D42	M	TDVR	2	1	22.6	116	5.1	5.8	4.6			45.1 (31.7-56.8)
D47	F	TDR	7	1	40	118	3.0	3.7	2.5	200		27.1 (18.1-27.1)
D60	F	TDR	3	0	75.5	288	3.8	4.1	3.5			60.5 (58.1-76.7)
D63	M	Thermal	2	1	21.6	120	5.6	5.8	5.4			57.6 (51.6-61.3)
D227	M	Thermal	3	1	73.5	370	5.0	6.4	3.6			39.2 (23.9-55.5)
D230	F	TDVR	2	1	14.8	62	4.2	5.0	4.0	41	3.62	34.9 (31.7-38.8)

Table 3. Summary data for the 6 dolphins tracked via satellite.

Dolphin ID	Sex	Track Length (days)	Total Distance Traveled (nm)
D13	M	3	248
D28	M	7	530
D30	F	8	376
D38	M	20	454
D62	F	2	152
D228	M	4	202

Table 4. Time-depth-velocity recorder (TDVR) data for D19 and D230 summarized for the following purse-seine fishing events: chase (*i.e.*, when the helicopter is overhead prior to net let-go), in the net, post-release (*i.e.*, after released from the net during backdown), and while being tracked: night and day. The times given for each purse-seine activity is the length of time the velocity was observed to be different that the average observed during tracking when not involved in making a set. The length of chase is the elapsed time from when the helicopter is over the herd to net let-go. The length of the post-release interval is the elapsed time that velocity is observed to be greater than the average daytime or nighttime velocities and before regular diving behavior is observed.

	Chase		**In the net**		**Post-release**		**Day**	**Night**
Dolphin ID	Ave. Velocity (kn)	Time (min)	Ave. Velocity (kn)	Time (min)	Ave. Velocity (kn)	Time (min)	Ave. Velocity (kn)	Ave. Velocity (kn)
D19	3.38	32	1.71	110	5.23	106	3.01	2.41
D230	5.66	15	1.24	85	6.22	90	3.58	3.85

Figure 1. All sets made during the 2001 Chase Encirclement Stress Studies (CHESS) cruise were made within the shaded rectangle.

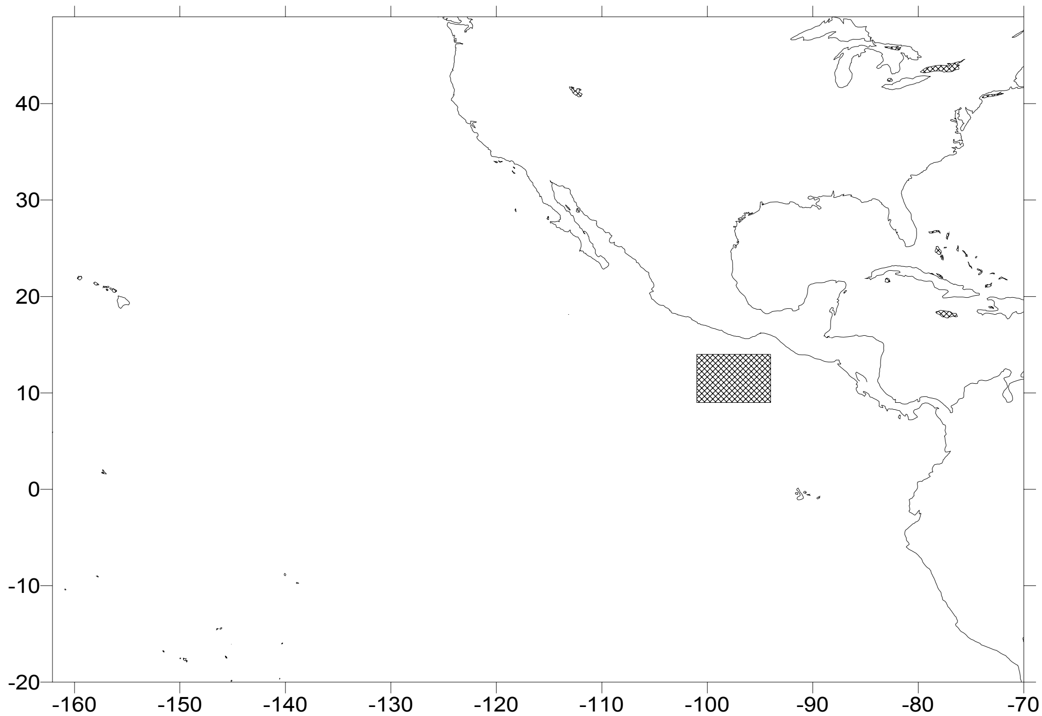


Figure 2. Tag packages deployed are drawn here in relative proportion to each other. (1) the 'boomer' VHF radio tag paired with a time-depth recorder (TDR), (2) the 'boomer' VHF radio tag paired with a time-depth-velocity recorder (TDVR), (3) the satellite tag, (4) the time-depth-velocity-heat flux recorder (or "thermal" tag), which was paired with a 'boomer' or 'bullet' VHF radio tag, (5a) the 'bullet' VHF radio tag, and (5b) the AgriTag roto tag. The flaps of the AgriTag roto tag were removed and the pins used to mount the 'bullet' tag. Both the 'bullet' and roto tag were attached through a small hole made in the trailing edge of the dorsal fin near its tip.

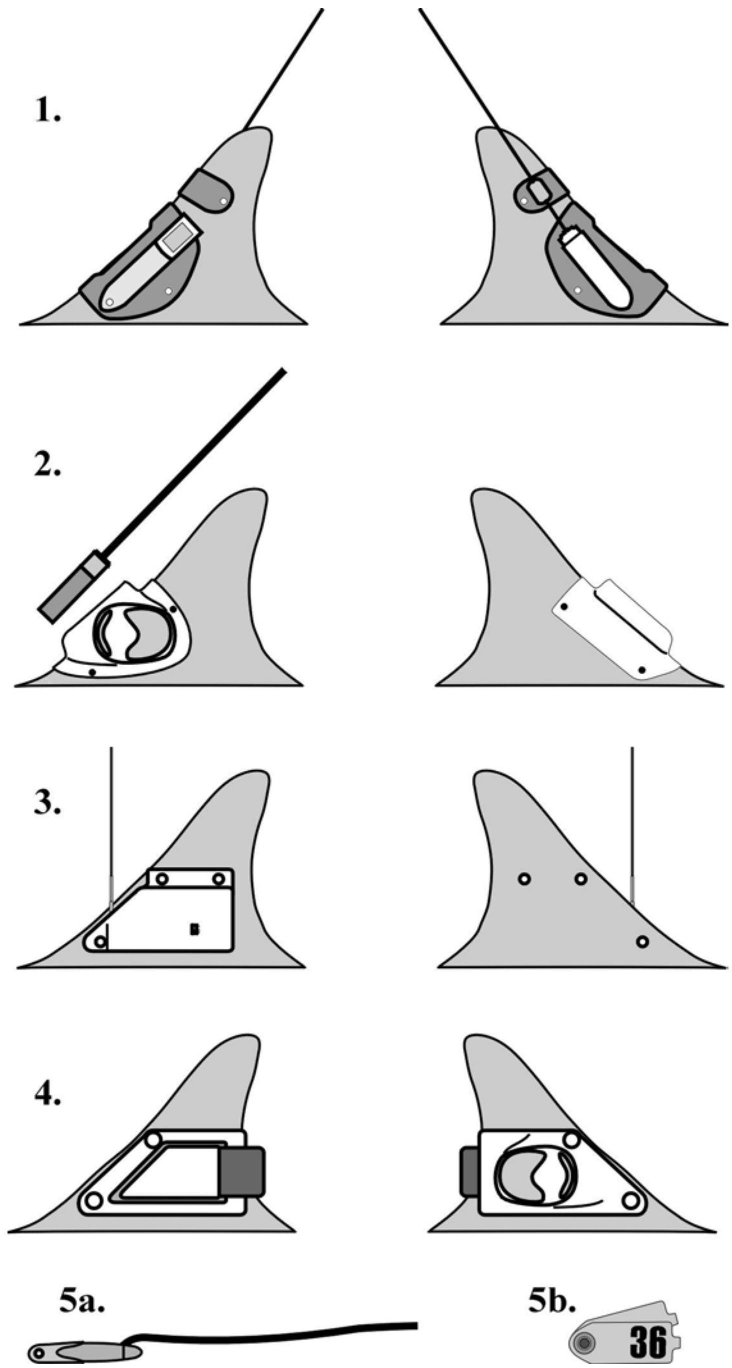


Figure 3. The track of D29 provides a representative example of the movement patterns observed during the tracks of all focal dolphins. However, D29's track was our longest and lasted 146.1 hours. Only the geographic positions recorded every 30 min during the track were plotted. Local time during the track is printed every 6 hours, and the date is printed at 0000hrs. Solid black dots mark the locations of sets made during the track.

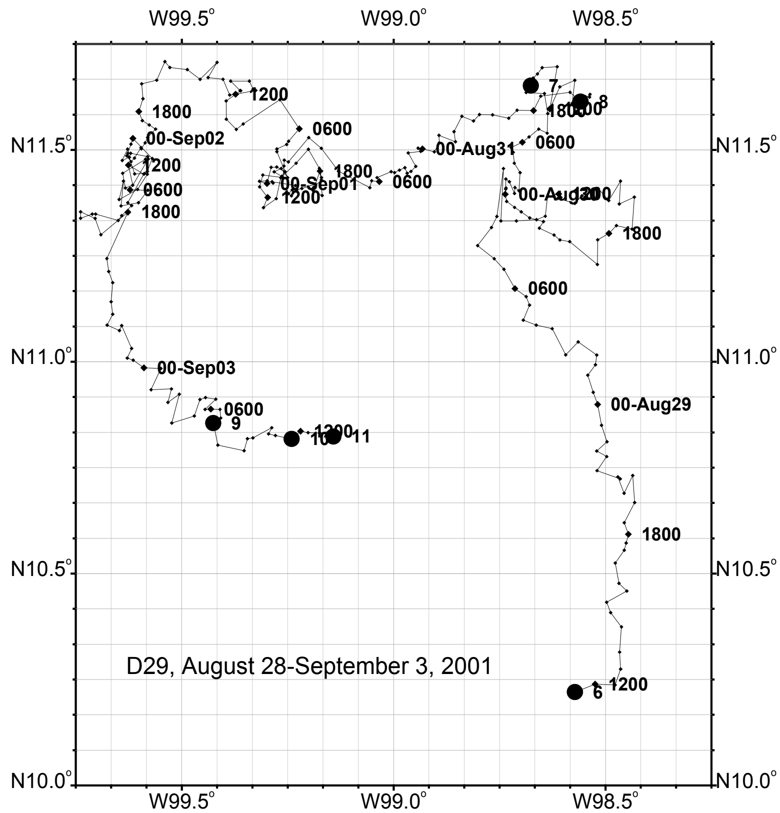
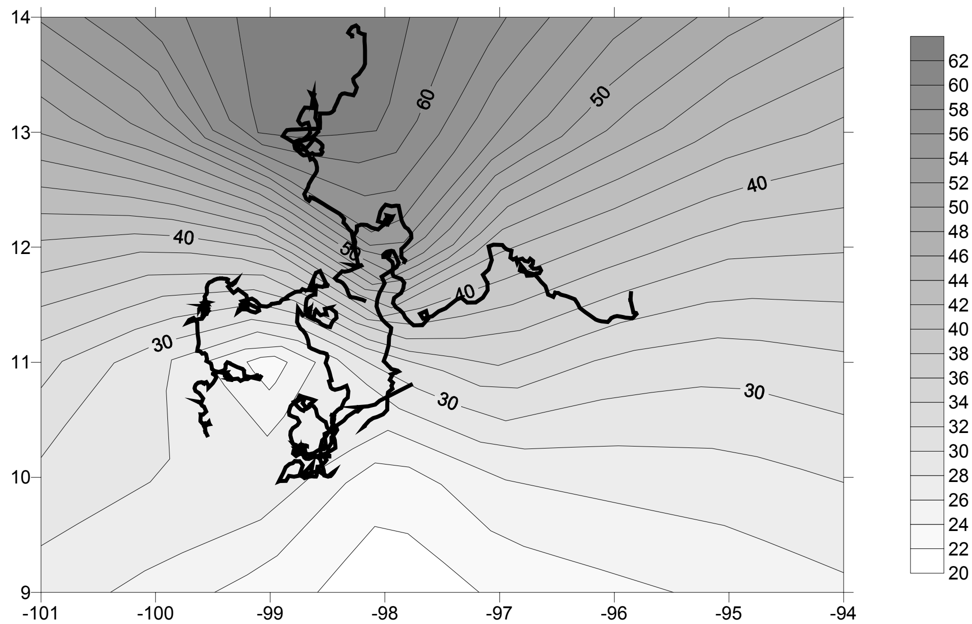


Figure 4. (A) A composite of all tracks recorded for the nine focal dolphins tracked are plotted over the contour map of thermocline depths. The thermocline was defined as the 20^{o}C isotherm and was recorded by expendable bathythermographs (XBTs) deployed approximately every 4 hours during a track. (B) An overlay of the composite track for the six satellite tagged dolphins is added in this plot.

(A)



(B)

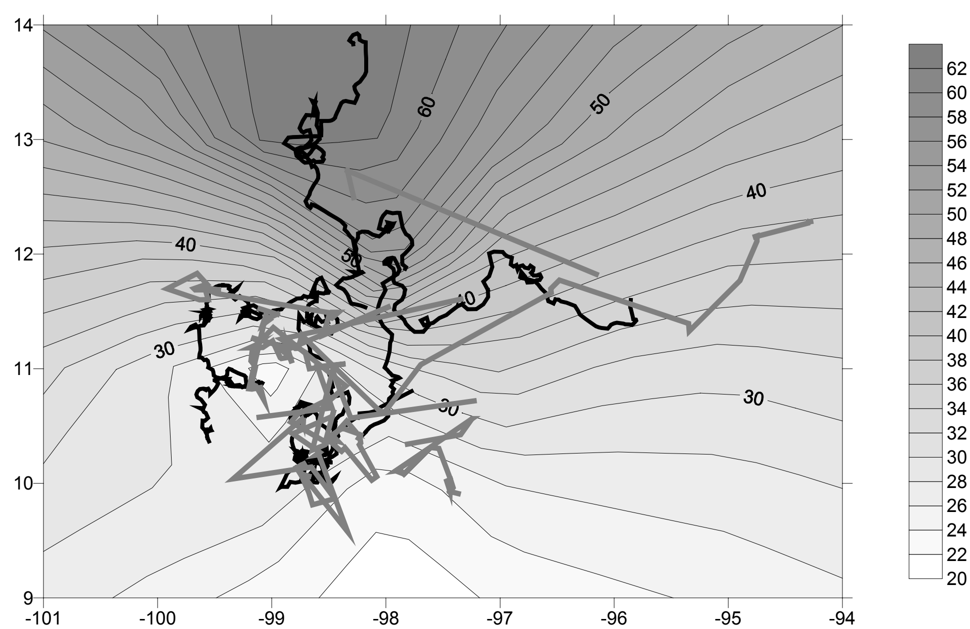


Figure 5. A sample of the daytime dive record collected for D230.

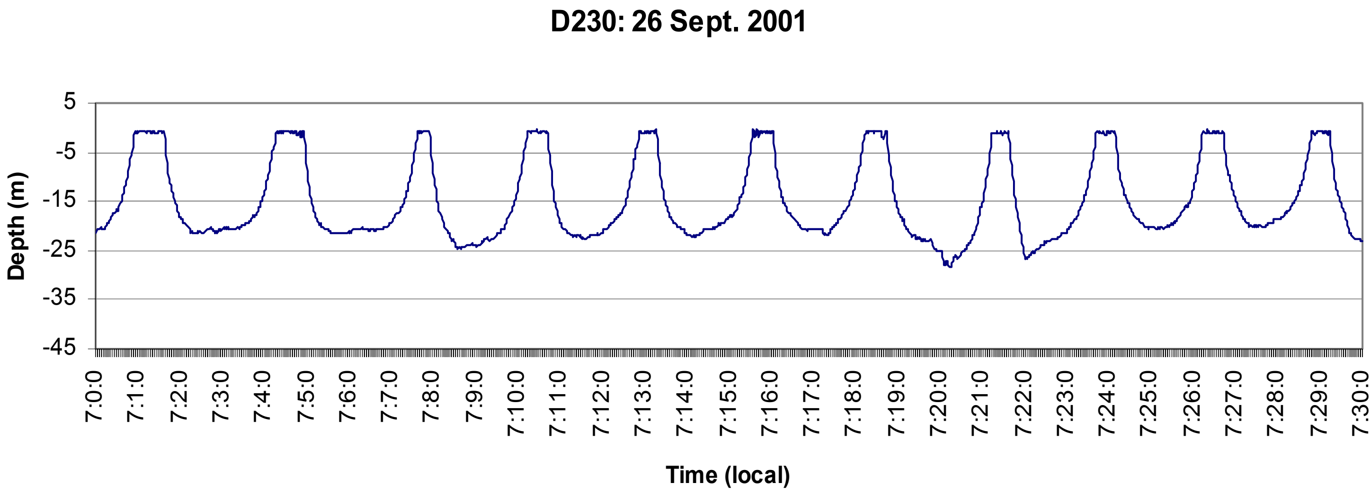
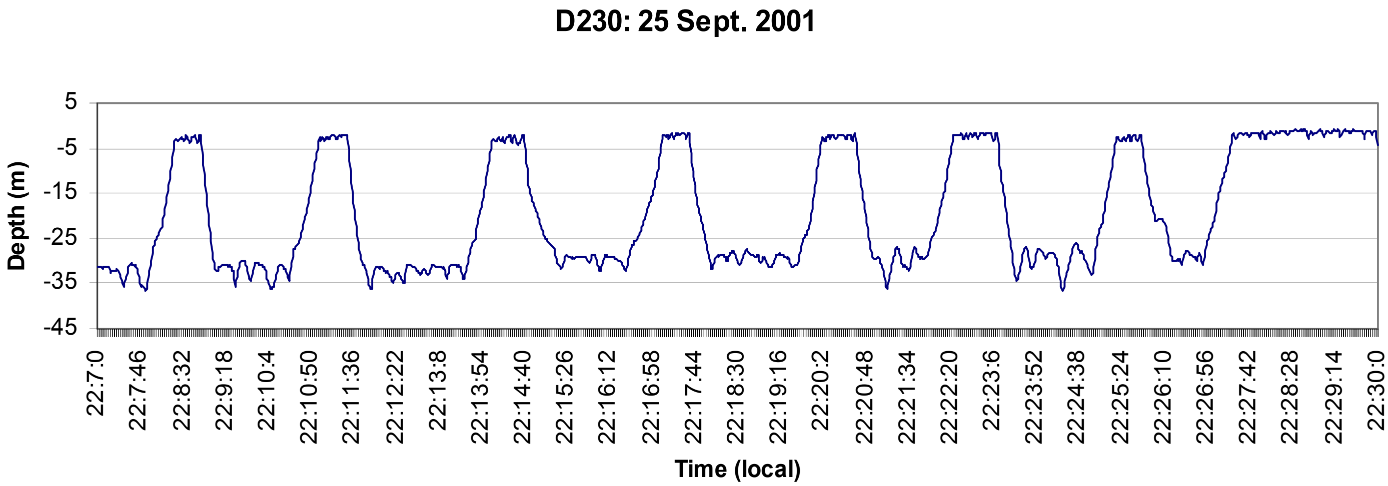


Figure 6. These two samples of the nighttime dive record collected for D230 show slightly different dive patterns observed during the same night.



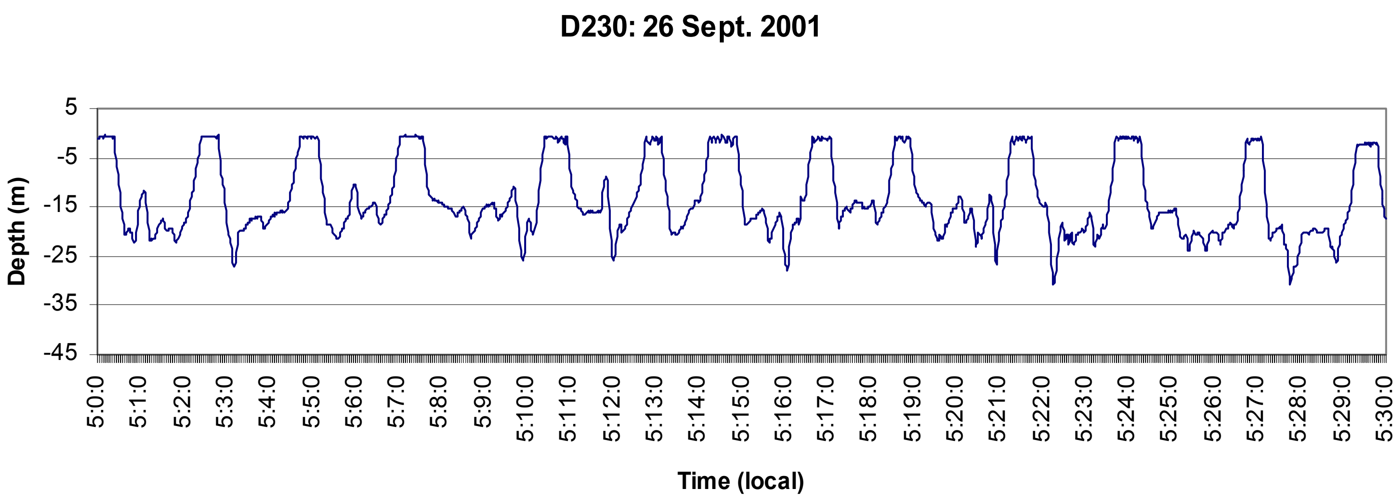
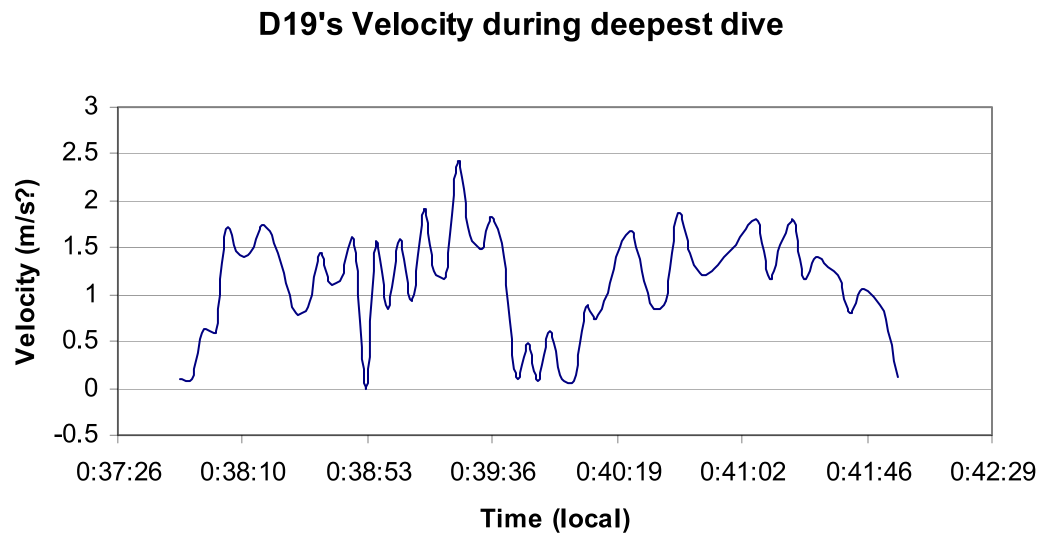
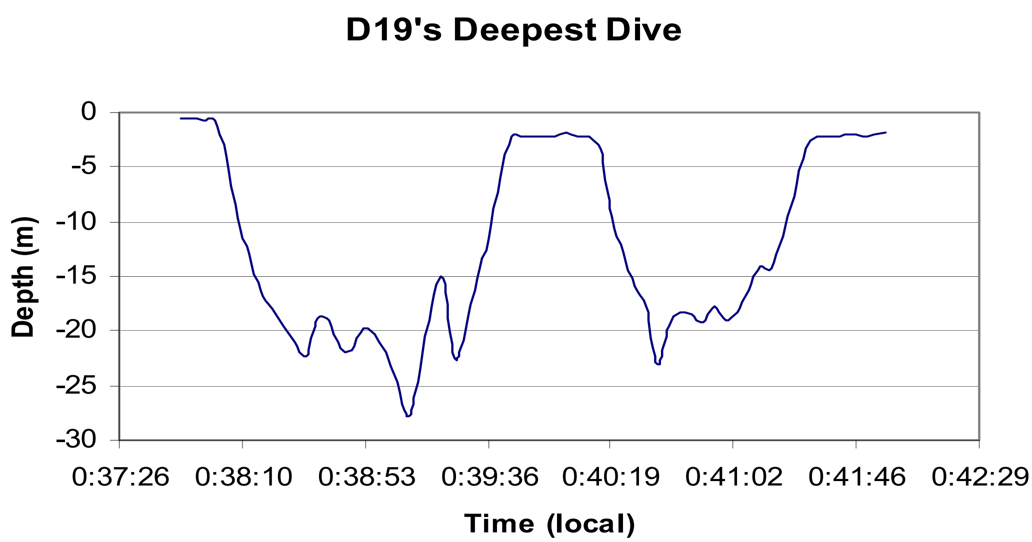


Figure 7. Sample velocity and dive profile. Only the deepest dive from D19's tag is shown.





APPENDIX - Responses to reviewer comments

Southwest Fisheries Science Center
8604 La Jolla Shores Dr.
La Jolla, CA 92037

18 April 2002

Southwest Fisheries Science Center
110 Shaffer Road
Santa Cruz, CA 95060

Dear Karin,

Michael Scott and I have carefully reviewed the comments we received on our paper (CIE-S05) presented to the Center for Independent Experts Stress/CHESS Review Panel. Below is our summary of reviewer comments and our responses to them.

1. Dr. G. Bossart raised several points pertinent to the interpretation of results from the CHESS experiment. Specifically, Dr. Bossart asked (1) could the methodology of sampling a smaller subgroup of a large dolphin herd cause the introduction of an experimental variable that caused the apparent highly fluid dynamic population?, and (2) could sampling a smaller subgroup actually contribute to the observed clinicopathologic parameters of acute "stress"? These are good questions and discussed in the Sampling biases and caveats section of Forney et al. (2002). Herds of pantropical spotted dolphins are known to be dynamic, so disruption of a permanent social structure was not likely. But whether capturing small subgroups of a herd results in more or less "stress" to the dolphins remains an open question. We might expect, however, that capturing fewer dolphins would result in the dolphins experiencing less "stress" because of less crowding inside the net.

2. Dr. S. DeGuise suggested that blood and skin samples collected during the study be used to evaluate tag attachments. Although this is a valid comment and would be a valuable contribution to the cetacean tagging literature, such an evaluation is beyond the scope of CHESS (although we have plans to look at this along with the tagging results from other studies in the future).

   Dr. DeGuise also expressed that more should be made of our observations that cow/calf pairs stayed together during multiple chases. We would like to explicitly document our observations. However, we consider these observations tangential to the topic of our paper and suggest that they be included in the CHESS synthesis document: Forney et al. (2002). Here is a paragraph detailing our observations.

   Mother-calf Bond

   It has been suggested that chase and encirclement may cause separation of mothers and calves that could result in unobserved calf mortality (Archer *et al*. 2000). Two focal dolphins tagged in this study (D29 and

D230: Chivers and Scott, 2002) and one in a previous study (D8: MS and SC, unpub. data) were mothers with calves. All three calves remained with their mothers after 7 chases over 7 days (D29), 2 chases over 2 days (D230), and 2 chases over 3 days (D8).

3. Dr. D. Martineau commented on the size of the telemetry packages and their potential effects on the dolphins' behaviors. The telemetry packages we used are extremely small compared to body mass. Typically radiotrackers of terrestrial mammals and birds attempt to design tags with masses less than 1-3% of the animal's body mass. The time-depth-velocity recorder (TDVR) packages we deployed were our largest ones and were less than 0.5% of adult body mass. More important to marine mammals, however, is that the packages be hydrodynamically designed to reduce drag. While one may expect some short-term behavioral changes due to the tags presence, the tagged dolphins' behavior in response to purse-seine operations were similar to those of all other dolphins in the herd, including dolphins that were tagged with smaller radiotags or visual tags.

   Dr. Martineau also wondered whether the dolphins diving within 5 m of the surface would have access to cold water in the net. It is difficult for us to conceive of a mechanism by which cooler water from below the thermocline depth could be brought near the surface by pursing the net. Divers swimming within the net did not detect cooler waters at those depths.

   He also requested that more detailed analyses of sprint speeds be done and that our observations be re-interpreted using an upper speed value rather than an average. There are many sources of inaccuracies and error in the estimation of travel speed. Most are difficult if not impossible to quantify. For this reason, we will remain with our presentation of average speeds for the dolphins tracked. There were "travel bursts" observed in our tracking records but none exceeded the estimated speed and duration of post-release behavior documented with the TDVRs.

4. Dr. R. Ortiz provided recommendations for focusing future tagging and tracking work but not suggestions for improvement of the manuscript.

Our manuscript remains fundamentally unchanged from that originally submitted to the Review Panel, and so we have not included another copy with this letter. We will, however, make some minor changes to our manuscript (e.g. add names to the acknowledgements) when re-formatting it as a SWFSC Administrative Report.

If you have any comments or questions about our responses, please contact me.

Sincerely,

Susan J. Chivers, Ph.D.
Research Fishery Biologist

cc. M. Scott, D. St. Aubin, S. Reilly